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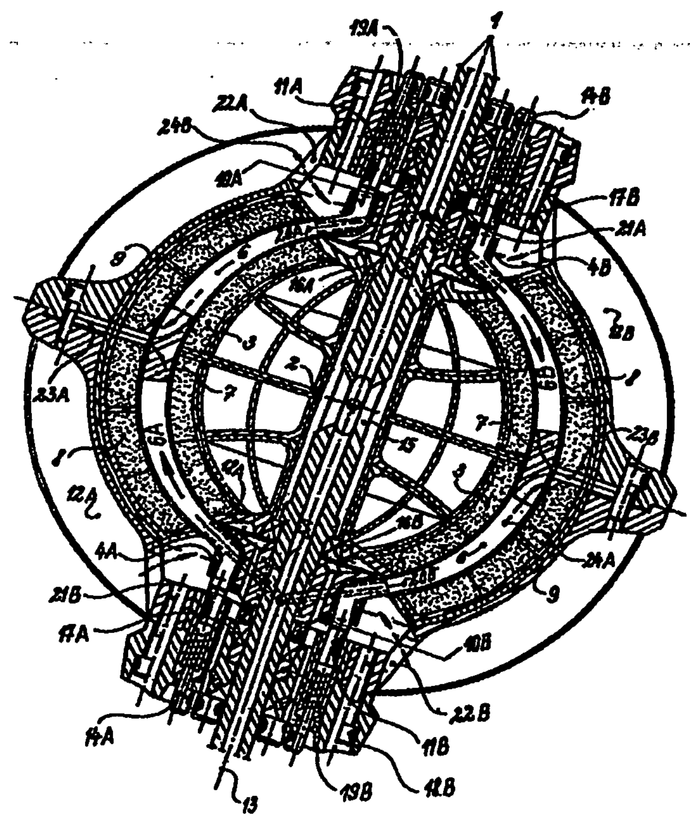
(54) Title: SPHERICAL, DIRECT CURRENT, CAGE ROTOR ELECTRIC MOTOR

(57) Abstract

The subject of the invention is a spherical, direct current, cage rotor electric motor which has a stator, composed of an inner part (2) made of a spherical shape, hollow, flux conducting soft magnetic yoke, and a surrounding outer part (3) made of a spherical shell shape permanent magnet, and a spherical shell shape caged rotor (6), made of copper profiles and surrounding the stator. The ends of the copper profiles from disk shaped commutators (10A, 10B), to which brushes (11A, 11B) are coupled. The caged rotor (6) is provided with a stiffening ring (7), and it is surrounded concentrically by permanent magnetic main poles (8), which in turn are surrounded by a shell structure (9) and casing parts (21A, 21B) provided with ventilating openings. The axle of the motor is a splined tububar shaft (1) in which openings (15, 20) are formed.



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TITLE: SPHERICAL, DIRECT CURRENT, CAGE ROTOR ELECTRIC MOTOR

Field of the Invention

The subject of the invention is a spherical, direct current, cage rotor electric motor.

Background to the Invention

A very wide scale of direct current electric motors is known. The direct current electric motors of the electric motor driven vehicles constitute one large group of them.

The US-PS No. 4 948 998 describes a twin-commutator, highly reliable direct current electric motor, provided with two independent, parallel windings, arranged in the rotor core. Through the bush systems located on both sides of the motor and through the commutator, the windings can be used separately or together. The rotor is cylindrical, non-self carrying and the stator contains field windings.

The scheme of an open squirrel cage direct current electric motor with commutators on both ends and with cylindrical iron cored rotor is described in publication sheet EP 0 481 774 (A2). It is suggested to use it primarily for large-current railway traction motors, however, the description does not provide dispositions, practical instructions or directions for the implementation of the magnetic circuit, bearing support, cooling, etc.

The 1989 product booklet of the ESCAP company (Switzerland) describes direct current electric motors with low moment of inertia and ironless rotor, where the self-carrying, cylindrical rotor is a so-called thread wound (compacted honeycomb) coil. This arrangement reduces the effective torque by about 30% and increases the length of the coil and its resistance in the same proportion. The direct current electric motors of small inertia and with ironless (hollow) self-carrying rotors, described in the 1989 product-booklet of the Pacific Scientific company (USA, Illinois) are similar to them.

From the US-PS No. 4 019 075 ironless rotor coils of miniature direct current electric motors can be learned. The multiple-wound lap windings have relatively large coil-heads, i.e. 'unused' parts. The self-carrying rotors developed by them are cylindrical with single-sided commutator.

Another cylindrical solution with single-sided commutator can be learned from US-PS No. 4 181 966, in which case the field magnet is located inside, while the soft magnet yoke is located outside of the rotor.

The field magnets of the direct current electric motor with cylindrical, ironless, self-carrying rotor according to the solution of US-PS No. 4 110 645 are located outside of the rotor, while the flux conducting yoke is located within the rotor.

A cylindrical, direct current, electric motor is described also in HU-PS No. 189 040, where the rotor of the implementation according to Fig. 2 thereof is a disk shaped wire coil, with

significant parasite coil-head wire lengths and masses. The double rotor and the commutators on the rotors of the solution according to Fig. 3 thereof are also disk shaped and made of printed circuits, while the bushes are directed radially.

An electric motor partly similar to the latter, with a rotor and commutator made of double printed circuit boards can be seen in Fig. 1 of US-PS No. 4 082 971, with the difference that the two rotors driving the same shaft have separate, independent stator magnetic circuits, since aluminum spacers and housing parts are located between the yokes.

Summary of the Invention

The need has arisen for low and medium current electric motors of better efficiency.

I have set as an objective of my invention to reduce the effect and mass of those components which increase the losses, therefore decrease the efficiency, and to increase the power per volume.

The key for the solution was given by the recognition that the source of the losses is primarily the exciting circuit of the motor, its inhomogenity and dispersion and, on the other hand, the added resistance loss caused by the relatively great length of the coil-heads of the rotor.

To exclude the above mentioned deficiencies and to satisfy the demands that have arisen, I have found a spherical arrangement suitable.

A solution for the optimal design of the exciting circuit is the use of high energy, double-sided permanent magnets, preferably made of alloys, the magnetic line of force of which is radial over a relatively large angular range, a direct consequence of which is that the (B) induction lines are perpendicular to the direction of the current (I), and further, to the generated force (F).

Shortly: it is easy to see the obvious fact that in case of the rotor of a spherical shape motor, the requirement of perpendicularity is satisfied at any point of the above mentioned angular range.

The second question, i.e. the design of the rotor is a more complex problem. With other words: a meaningful increase of efficiency can only be achieved by reducing the amount of energy transformed into heat according to the I^2R power formula. It can be regarded solved by using a spherical shell shaped rotor, made of copper profiles of relatively large cross section and strength which, at the same time, is suitable for transmitting torque.

The objective of the invention was achieved by designing a spherical, direct current, cage rotor electric motor, the stator of which is composed of an inner part, made of a spherical, hollow, flux conducting, soft magnetic yoke, and a surrounding outer part of spherical shell shape, consisting of segmental parts or cast over the inner part, and made of permanent magnet, the output axle is a splined tubular shaft, protruding through the hole of the inner part. The cage rotor is a spherical surface of revolution surrounding and enclosing the ferromagnetic stator of sandwich structure angular-symmetrically, which is composed of copper profiles, arched along

the planes parallel to the geometric axis of the splined tubular shaft, the insulated hub-parts of which are fixed to the splined tubular shaft by means of screw type clamping bushes, the ends of the copper profiles are machined into planes perpendicular to the geometric axis of the splined tubular shaft, and which form disk shape commutators, to the commutators bushes, preferably made of bronze-graphite or mercury, are resiliently coupled, whose terminals are formed as plug-socket holders or clamping screws. The inner part of the stator can be of meridian lattice structure. The caged rotor can have a form different from spherical, e.g. ellipsoid of rotation, eventually a discus form, nevertheless, it must be a body of rotation. The equatorial of the cage rotor has the shape of a torus, and it is provided with a fiber glass reinforced heat resistant plastic stiffener ring, which is concentrically surrounded by segmented permanent magnetic main poles, which in turn are surrounded by the shell structure of soft magnetic yokes made of two hemispherical-like parts that are pressed to one another at their edges, which in turn are surrounded by a light metal alloy, for example aluminum, hollow casing containing openings, and between the stator and the splined tubular shaft, and between the casing and the splined tubular shaft bearings, preferably roller bearings, and sealing elements are arranged. Within the splined tubular shaft, in the range of the geometric center of the motor, larger openings, and at the planes of the commutators, smaller openings and gilled air-inlet ports forming carburatter chokes are formed.

The casing can be made of two hemispherical parts provided with ventilating openings, and they can be fixed together by, for example, bolts, however, a spherical plastic net or lattice work of appropriate strength can also be used. From the outer mantle of the caged rotor, at the dividing plane, air-outlet channels having a tangential outlet end sections are formed in the permanent magnetic main poles, in the soft magnetic yoke shell structure, as well as in the casing parts. Tangential baffles are arranged at the outlet part of said end section.

Brief Description of the Drawings

The spherical, direct current, cage rotor electric motor according to the invention is described below in more details, by an example embodiment, and with the help of the attached drawing, in which in Figure 1 the cross section of the motor is seen; in Figure 2 a more detailed cross section is shown.

Detailed Description

The motor thus has a splined tubular shaft 1, which has, at its larger diameter middle section, a stator, which comprises a spherical, hollow inner part 2 made of a flux conducting soft magnetic yoke, and a permanent magnetic outer part 3 surrounding said inner part 2, which consists of segmental parts or which is cast onto the inner part 2. The stator is surrounded by an angular-symmetric, spherical shell surface of revolution shaped cage rotor 6, which is made of copper profiles, preferably profiled plates or rods,

that are arched in planes parallel to the geometric axis 13 of the splined tubular shaft 1, the ends of the profiles constitute, at the splined tubular shaft 1, the commutators 10A, 10B, ... of disk segment shape, which are machined into a plane perpendicular to the geometric axis 13 of the splined tubular shaft 1. Close to the commutators 10A, 10B, ...brushes 11A, 11B of disk segment shape sit resiliently, made preferably of bronze-graphite, the terminals 14A, 14B of which are formed as plug-socket holders or clamping screws. The insulated hub parts 4A, 4B; 5A, 5B are fixed onto the splined tubular shaft 1 by means of the screw type clamping bushes 21A, 21B.

At its biggest diameter, i.e. equatorically, the caged rotor 6 is strengthened by a ring 7 made of insulating material, preferably fiber glass reinforced heat resistant plastic, which is press molded - by forming air channel(s) therein simultaneously - onto the cage rotor 6, already mounted on the stator. The cage rotor 6 is surrounded by permanent magnetic main poles 8 shaped as spherical shell segments, bordered by planes parallel to the geometric axis 13 of the splined tubular shaft 1, the permanent magnetic main poles 8 in turn are surrounded, also in the shape of a spherical shell, by the shell structure of soft magnetic yokes 9, split along the biggest diameter ('equator'). The direction of the developing magnetic field in the space between the permanent magnetic main poles 8 of the assembled motor is radial.

Finally, the outer part of the spherical, direct current, cage rotor electric motor is composed of by the casing parts 12A and 12B,

which, too, are spherical, fixed together by bolts at their biggest diameter, provided with gill-openings and preferably are webbed on their outside, and made of light metal alloy, for example aluminum.

Instead of the casing parts 12A and 12B, a spherical plastic web or lattice work can also be used.

Between the hollow inner part 2 and outer part 3 of the stator and the splined tubular shaft 1, roller bearings 16A and 16B and bearing boxes 18A, 18B, provided with bores, and between the casing parts 12A, 12B and the splined tubular shaft 1 roller bearings 17A, 17B and sealing elements 19A, 19B are arranged. In the range of the geometric axis of the splined tubular shaft large openings are formed. The bores of the bearing boxes 18A, 18B connect the openings 15 with the space of the cage rotor 6.

For the operation of the spherical, direct current, cage rotor electric motor according to the invention it is preferable to use compressed air, which coming from one (or both) end(s) of the splined tubular shaft 1, traveling within it, enters the interior of the motor by passing through the openings 15 of the splined tubular shaft 1 in the range of its geometric center, as well as through the smaller openings 20A, 20B, provided in the splined tubular shaft 1 at the planes of the commutators 10A, 10B, then it leaves the motor through the bores of the bearing boxes 18A, 18B and through the (not shown) gill-openings of the casing parts 12A, 12B.

In Figure 2, naturally, the same reference numbers refer to the same elements. Furthermore, at the planes of the commutators 10A, 10B carburatter chokes 22A, 22B, and from the outer mantle of

the caged rotor 6, at the dividing plane, air-outlet channels 23A, 23B having tangential outlet end sections are formed in the permanent magnetic main poles 8, in the soft magnetic yoke shell structure 9, as well as in the casing parts 12A, 12B. The paths of the air flow 24A, 24B are shown by dashed lines.

The operation of the spherical, direct current, cage rotor electric motor according to the invention is the following:

Similarly to the known motors, its operation is based on the fact that a force acts on a conductor in which a current flows and placed in a magnetic field.

When a current flows in the conducting elements 6A, 6B, ... of the cage rotor 6, shown in the figure, in the direction indicated by the arrow, then a force acts on the left hand side arched conducting element 6A, upwards from the plane of the sheet, and on the right hand side arched conducting element 6B downwards from the plane of the sheet, as a direct result of which is that the cage rotor 6 attempts to rotate the splined tubular shaft 1 counter clockwise.

If the direction of the current is reversed, the cage rotor 6 will rotate clockwise.

It is easy to see, that if the direction of the current is reversed at each half-rotation, the continuity of the rotation can be maintained. Following the path of the air flow, it is easy to see as well that the motor acts at the same time as a centrifugal blower or turbine of double-side inlet, provided with meridian baffles.

All electromotive force is the result of an energy transformation E. The matter is that there is another fundamental and

simple relationship between the electricity, mentioned before, and the magnetism, which is invariant with the known physical laws, and can be developed into a new equation, which gives the following relationship of energy equilibrium for spherical motors and generators:

$$2\pi Mn = EI = I^2 r\omega$$

If I is given in A, r in m, ω in s^{-1}, then the induced electromotive force E is obtained in V, and the whole magnetic torque exerted by the motor is obtained in Nm.

The advantages of the spherical, direct current, cage rotor electric motor, constituting the subject of my invention, are the following:

- Independent of their geometric sizes, the efficiency of all spherical, direct current, cage rotor electric motors is the same, which exceeds 90%;

- The spherical shape of the rotor and the strong magnetic field, which is practically radial over a large angular range, makes it possible that the improductive length of the wires is the smallest possible, and there is no coil-head;

- The moment of inertia of the self-carrying 6 cage rotor is small and, further, there is no wattless component arising from the coil-heads, therefore the motor is especially suitable for fast (for example servo) drives;

- Because of the higher efficiency, motors of smaller mass and volume can be produced, which are especially advantageous in case of airborne systems, for example, on aircraft, satellites, etc.;

- The reliability of the motor is higher, and the life of the bushes is longer, due to the double commutator and brush system;

- By means of higher current open cage rotors and by increasing the number of brushes and the number of copper profiles or rods, i.e. the conducting elements, constituting the caged rotor, the pulsation of the shaft-torque can be reduced, which makes the use of inertia masses other than the strengthening ring unnecessary in case of, for example, tired vehicles, motor cycles, cars, etc.;

- Due to the practically closed magnetic field, the detrimental parasitic magnetic radiation of the motor can be significantly reduced, which is advantageous, for example, in case of airborne systems;

- It is easy to use, in connection with the motor, different kind of semiconductor pulse-width modulated choppers (realized by tyristors, GTO tyristors, transistors and POWER-MOSFET elements);

- The ironless caged rotor also acts as a centrifugal blower or turbine of double-side inlet, provided with meridian baffles;

- The splined tubular shaft makes it possible to use the motor as a single-flow propeller turbine, for example in case of sport aircraft.

Claims

1. A spherical, direct current, iron-free cage rotor electric motor, which has conducting terminals, stator and rotor and an output axle, **c h a r a c t e r i z e d i n** that

- the stator is composed of an inner part (2) which is made of spherical shape, hollow, flux conducting soft magnetic yoke, and an outer part (3) made of a spherical shape permanent magnet consisting of segmental parts or cast upon the inner part (2) and, thus, surrounds it,

- the output axle is a splined tubular shaft (1) protruding through the cavity of the inner part (2),

- the caged rotor (6) is a surface of revolution, preferably a spherical shell shape, surrounding and enclosing the ferromagnetic stator of sandwich structure angular-symmetrically, composed of copper profiles that are arched along planes parallel to the geometric axis (13) of the splined tubular shaft (1), the insulated hub parts (4, 5) which are fixed to the splined tubular shaft (1) by means of threaded clamping bushes (21A, 21B), and their ends at the splined tubular shaft (1) are machined into planes perpendicular to the geometric axis (13), and they form disk shaped commutators (10A, 10B),

- to the commutators (10A, 10B) brushes (11A, 11B), preferably made of bronze-graphite or mercury, are resiliently coupled, whose terminals (14A, 14B) are formed as plugs or clamping screws,

- the shape of the equator of the caged rotor (6) is a torus and it is provided with a stiffening ring (7) made of fiber glass reinforced, heat resistant plastic, and it is surrounded concentrically by spherical shape, segmented permanent magnetic main poles (8),

- the main poles (8) are surrounded by the shell structure (9) of soft magnetic yokes made of two hemispherical parts, fixed together at their edges, which in turn is surrounded by a casing made of light metal alloy or plastic and containing ventilating openings,

- between the stator and the splined tubular shaft (1), and between the casing and the splined tubular shaft (1) roller bearings (16A, 16B; 17A, 17B) and sealing elements (18A, 18B; 19A, 19B) are arranged,

- in the splined tubular shaft (1), at the range of the geometric center of the motor, larger openings (15), at the planes of the commutators (10A, 10B) smaller openings (20) are provided.

2. A motor according to Claim 1, c h a r a c t e r i z e d i n that the casing is made of two, hemispherical aluminum case parts (12A, 12B) which are provided with gill-openings.

3. A motor according to Claims 1 or 2, c h a r a c t e - r i z e d i n that air flow channels are formed in said stiffening ring (7).

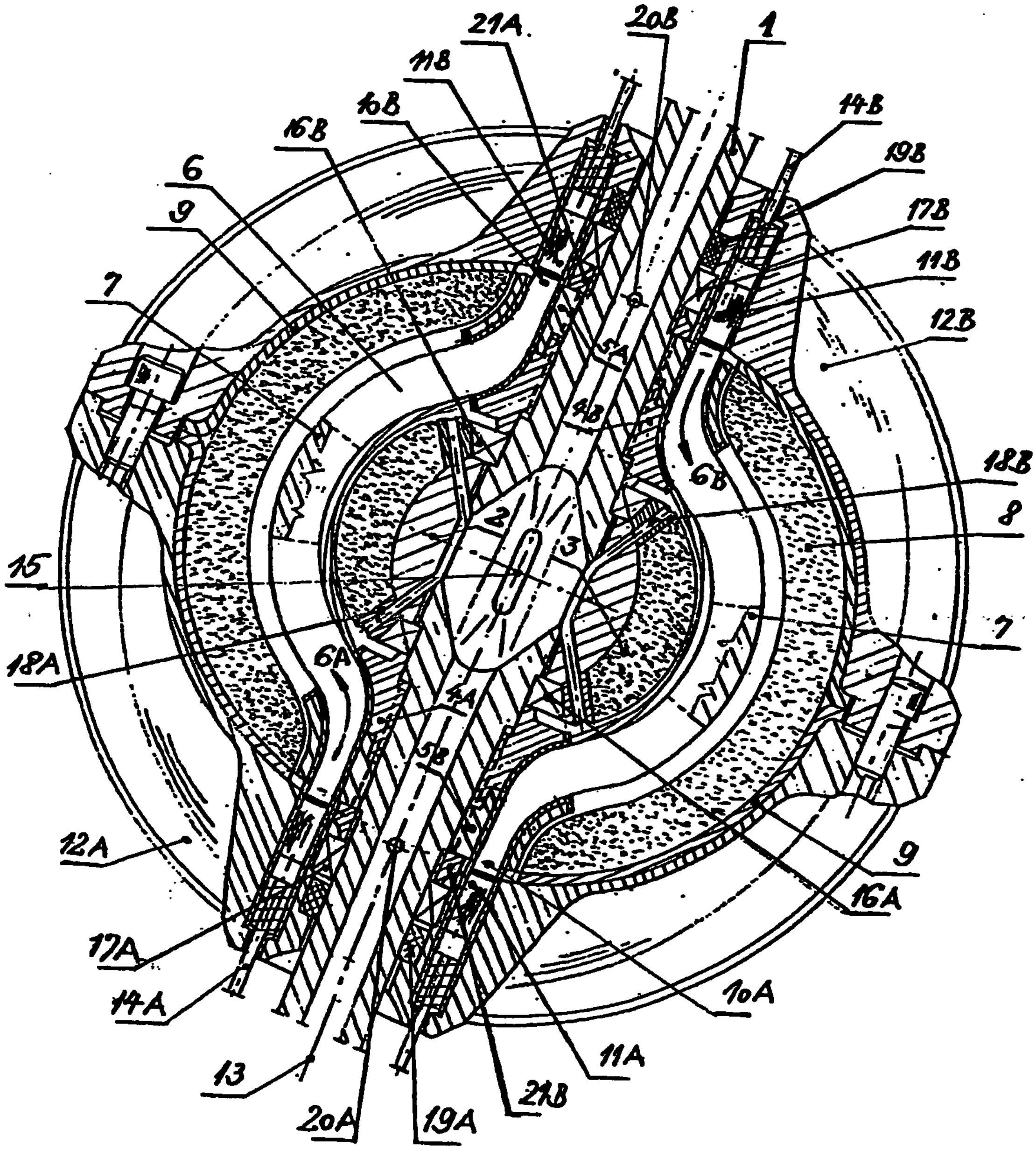
21A
20B
1
11B
10B
16B
14B
19B
6
9
17B
11B
7
12B
5A
4B
6B
18B
2
3
8
15
7
18A
6A
4A
5B
9
12A
16A
17A
10A
14A
11A
13
21B
20A
19A

FIG. 1

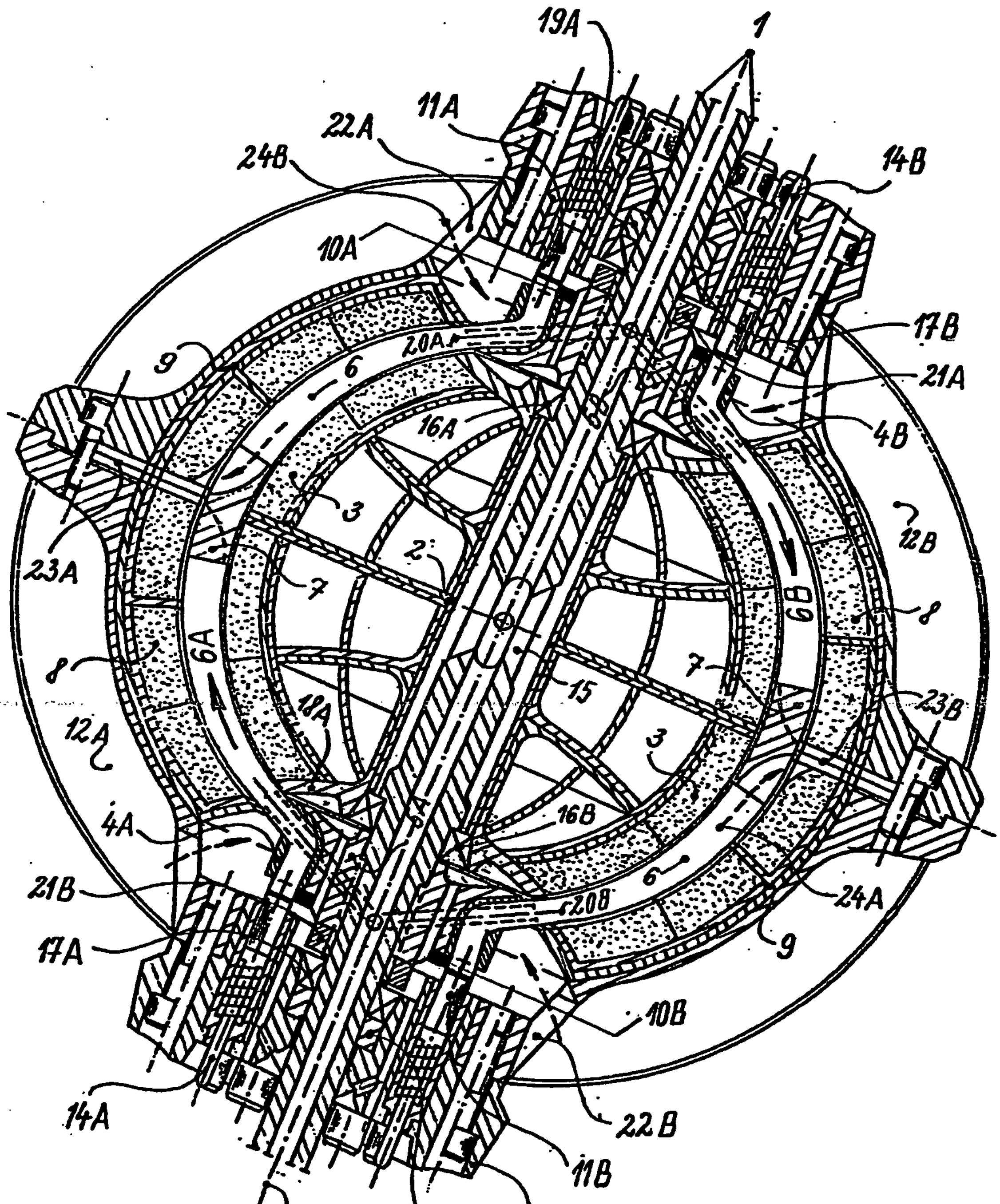
1
19A
11A
22A
24B
14B
10A
17B
20A
21A
9
6
16A
4B
3
12B
2
23A
7
6B
8
6A
15
7
8
23B
12A
18A
3
16B
4A
6
24A
21B
20B
17A
9
10B
14A
22B
11B
13
19B
18B

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/HU 98/00058

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H02K23/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CH 102 118 A (WILLIAM BROOKS SAYERS) 16 November 1923 see page 2, left-hand column, line 23 - page 2, left-hand column, line 43 see page 3, right-hand column, line 32 - page 3, right-hand column, line 43 see figures 16-19 ---	
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 017 (E-223), 25 January 1984 & JP 58 179153 A (ENTATSUKU KK), 20 October 1983 see abstract ---	
A	US 3 312 846 A (JACQUES HENRY-BAUDOT) 4 April 1967 ---	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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13 October 1998	20/10/1998

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INTERNATIONAL SEARCH REPORT

Inte ional Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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